

## THE CHARACTERIZATION OF ODOURS

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The cardinal difficulty in work on the stimulation and perception of the chemical senses has always been our inability to characterize the stimulus. The stimuli for vision and hearing can be characterized in terms of frequency and intensity and those for some kinds of touch in terms of pressure and temperature, but there are no recognized terms of reference for smell and for taste. This paper is concerned with describing a new approach to the characterization of smells.

*Historical review*

A logical preliminary to the characterization of odours would seem to be their classification, and several schemes to sort out the multitudinous smells that we know have been propounded; the best known are those of Zwaardemaker and Henning. Zwaardemaker (1895) suggested that all odours could be accommodated in nine classes, viz. ethereal, aromatic, balsamic, ambrosial, alliaceous, empyreumatic, caprylic, repulsive, and nauseating; each of the nine classes had two or more subdivisions, e.g. the balsamic class was subdivided into (a) floral, (b) violet and (c) vanilla and coumarin odours. Henning (1916), after careful analysis, suggested that all odours were based on six fundamental odour groups, viz. spicy, flowery, fruity, resinous, burnt, and foul, although two or three of these primary odours might be present together in a single smell.

Whilst these classifications brought a certain amount of order to what had hitherto been chaotic, they were both entirely subjective and they certainly did not provide any more precise method of characterizing a particular odour than to say it was 'floral' or 'rose-like'. In particular, new odours such as those of new synthetics could not be adequately described.

An ambitious attempt to resolve the difficulty was made by Crocker & Henderson (1927), who postulated that there were four fundamental types of smell, just as there are the four fundamental tastes of sour, sweet, salt and

bitter, and that these four fundamental smells were served by four kinds of olfactory nerve endings. The four postulated fundamental odours were fragrant, acid, burnt and caprylic (goaty) and any given odour could be built up of these four fundamental odours; their relative degrees of stimulation determined that given odour. Any fundamental odour could be present in any given odour in intensity varying from one (very weak) to eight (very strong), and its absence could be denoted by zero. Consequently all the numbers from 0000 to 8888 represented different odours, e.g. the rose smell was represented by the number 6423 indicating that the

fragrant smell is stimulated to a degree of 6			
acid	„	„	4
burnt	„	„	2
caprylic	„	„	3

The method has received more attention than might have been expected, e.g. a series of twenty-two isomeric octanols prepared by Dorough, Glass, Gresham, Malone & Reid (1941) had their odours described in accordance with this system. Whereas 7-methyl-heptanol-1 had an odour described as 5425 (5 fragrant, 4 acid, 2 burnt, 5 caprylic), that of 7-methyl-heptanol-2 was 5325 and that of 6-methyl-heptanol-1 was 5326. This method also is entirely subjective and the only nose with which the author is personally acquainted registers only confusion and bewilderment when asked to analyse the smell of ginger or cloves or hyacinth into so many parts fragrant, so many acid, burnt and goat-like. There are, of course, artist perfumers, just as there are tea and whisky tasters, and such experts have learnt to discriminate very nicely between odours that to the layman are much the same, but no attempt is ever made by them to describe such niceties of difference in scientific terms; often such differences are almost impossible to describe in words at all.

Bienfang (1941) has suggested that odours may be characterized by clarity, strength, note, and persistence, but whether this advances our understanding of the subject is doubtful; it is the single property—the note or quality—that we want to characterize.

Several attempts have been made to correlate odours with vibrations of characteristic frequencies. More than eighty years ago Ogle (1870) wrote 'that the undulatory theory of smell... may, perhaps after all, be the true one'. Heyninx (1917) attributed odour to absorption of ultra-violet light by the vapours of odorous substances, but such associations were very irregular; e.g. iodoform and cinnamic aldehyde had practically the same absorption bands, but had very different odours. Dyson (1938) attempted to correlate odour with the Raman spectrum of a substance. Beck & Miles (1947) put forward some experimental results from the insect world that suggested that odour was concerned with absorption in the infra-red region, but according to

Johnston (1953) their infra-red loss theory of olfaction is untenable. Much earlier Grijns (1918), after a critical survey of the already reported cases of absorption of infra-red radiation by odorous substances had failed to correlate smell intensity with the capacity of a substance for absorbing radiant heat.

None of the attempts to correlate odour quality with a vibrational frequency has been successful, and one cannot but agree with Naves who in 1951 wrote: 'I cannot bring myself to find any reason whatever in this theory that odour is connected with vibrations in the molecule or of the molecule . . . (it is) absolutely without experimental foundation.' So far, then, no method of characterizing odours, other than a rough classification by subjective appraisal, has emerged and there is no present hope that a characterization on a frequency basis may be forthcoming.

### *Mechanism of olfaction*

In looking for a means of characterizing odours objectively by some number, curve, or quantity, it should be helpful to follow as closely as may conveniently be possible, those processes which take place in the nose when olfaction is ordinarily experienced. The information that we have and the theories that have been advanced on this subject have been reviewed elsewhere by the author (Moncrieff, 1951); all the evidence points to odour being airborne and to the necessity of actual contact of particles or molecules of the odorous substance with the receptors of the olfactory nerve. Whether olfaction is purely and simply the result of adsorption of the odorous molecules on the tissues, whether solution in the lipids is necessary, or whether chemical reaction takes place between odorant material and receptor is still debatable, but certainly the first action is one of contact and is a surface effect.

If *in vitro* we wish to destroy or abolish an odour, we can either dissolve the substance which has the offensive odour in a scrubbing tower, we can change it chemically, e.g. by oxidation, or we can adsorb it on some surface active material. Most of the unwanted odours of industry can be satisfactorily dealt with by one or other of these methods, although there are still a few, notably those of the moulds in antibiotic factories, which are troublesome. The methods that are used for the industrial destruction of odours are in principle the same as those which we believe to form part of the process of olfaction. Possibly adsorption alone is sufficient to account for olfactory stimulation; all adsorption processes are exothermic and the heat energy given out would constitute that energy necessary for stimulation of the olfactory nerve. A mechanism of qualitative discrimination of odours on a temporal and spatial basis has been described by Adrian (1949). So far as our knowledge goes, the process of adsorption corresponds most nearly to those processes that take place in the nose when we experience smell, although it is

true that we cannot exclude the possibility that solution and chemical reaction are other processes that may play very significant parts.

If adsorption is the main olfactory process, as seems to be likely, there must be *selective* adsorption to account for the large number of qualitatively distinguishable odours, and to account, too, for the spatial differences in stimulation which Adrian has shown to obtain in the nose of the rabbit according as the odorous material has an oily or a fruity smell. There must be receptor sites which differ from each other in molecular configuration and which selectively adsorb the odorant molecules; some will adsorb those of an oily nature, others those that are typical esters with fruity smells.

To the best of our knowledge, odour perception and discrimination are based on a natural process of selective adsorption that takes place in the nasal orifices. If, therefore, a method is to be chosen for the characterization of odours it seems logical to follow Nature so far as possible and to use a process of selective adsorption. It will be quite impossible to use the same adsorbent material as nature uses, but it may not be without interest to see what can be done with those adsorbent materials that are commonly available.

#### METHOD AND APPARATUS

The general idea was to see if some odorant materials were adsorbed readily by some adsorbents and less readily or hardly at all by other adsorbents, and to see if other odorant materials behaved dissimilarly. Was it possible that substances that had similar odour would have similar adsorption characteristics?

For the purpose of the preliminary investigation that is described in this paper, five adsorbents were used. They were:

1. Activated charcoal supplied by Sutcliffe Speakman and Co. Ltd., Leigh, Lancs. Quality 208C, a type recommended for general deodorizing. 6-10 mesh.
2. Silica gel supplied by Silica Gel Ltd., London. A type recommended for drying and conditioning air. 6-8 mesh.
3. Activated alumina supplied by Peter Spence and Sons Ltd., Widnes. Type 'A'. 4-8 mesh.
4. Activated fuller's earth supplied by Attapulugus Minerals and Chemicals Corporation, Philadelphia. Grade 'A', R.V.M. 6-8 mesh.
5. Vegetable fat. National 'Special' margarine was melted over near-boiling water, cooled and the solid fat removed. Some of this was melted and mixed with 3 times its own weight of activated alumina 8-16 mesh, by which it was well absorbed. The alumina acted purely and simply as a vehicle or holder for the fat.

The first step was to select some relationship between adsorbent and odorant. There were various possibilities, e.g. percentage of its own weight of odorant material that the adsorbent would pick up, or perhaps the change in concentration of odorant in odorized air passing through an adsorbent bed. However, smelling is a rapid process; there is no noticeable delay and it was desired to keep as nearly as possible to ordinary conditions of smelling. After a number of trials the quantity selected was the time of contact necessary for the adsorbent (in large excess) just to deodorize odorized air. As will be seen later, this time was very variable from one odorant to another, but provided that the adsorbent material would adsorb the odorant at all, the critical time of contact (as it will henceforth be referred to) was usually within the range 0.04-1.0 sec. This quantity seemed to be constant for any pair of odorant and adsorbent materials; it could be measured with an accuracy of about plus or minus 20%, which is reasonably good for measure-

ments involving odour, and by taking five observations for each pair a reasonable mean value for the critical time of contact was obtained.

The apparatus used was as shown in Fig. 1. *A* is a small electrically driven air-blower which has been calibrated to blow air at speeds from 10 to 40 c.c./sec. *B* is a 6 oz. bottle containing 15 ml. of the odorant material, the air from *A* being blown over the odorant material in *B* and thence up *C* which is a glass tube of 0.5 cm<sup>2</sup> internal section and which is graduated from the bottom upwards in cm. This tube *C* is packed to a height of say *n* cm with the adsorbent, e.g. activated carbon. In operation the upper end of tube *C* is inserted into one nostril, the blower *A* is started at its minimum speed, and the air speed gradually increased until the smell of the odorant material in *B* is just unmistakably recognizable at the outlet end of tube *C*. It is found

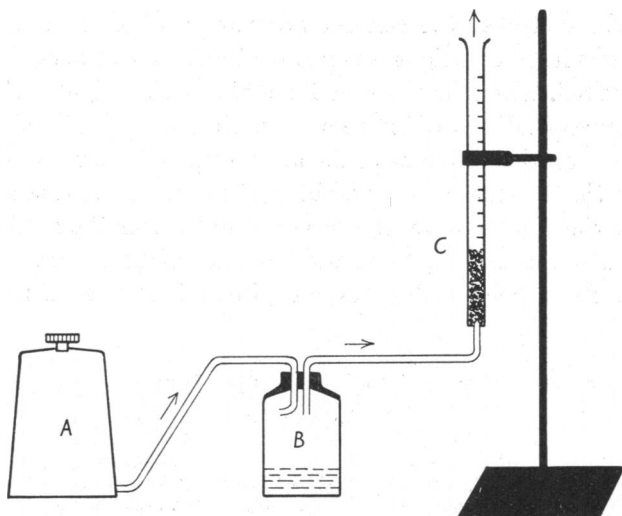


Fig. 1. Diagrammatic representation of apparatus used for determining critical times of contact of odorant-adsorbent pairs. *A*, air blower; *B*, odorant bottle; *C*, adsorbent column.

in practice that with a suitable height of adsorbent column, the smell of the odorant material cannot at first be detected at the outlet end of tube *C* but that as the air speed is gradually increased it is detectable. Sometimes there is a vague ill-defined awareness of a smell at the outlet end of *C*, which cannot, however, be recognized as the known smell of the odorant; this sub-smell is not taken notice of but the first appearance of a recognizable smell is the point observed. Each observation takes about 20–30 sec and as a fresh charge of adsorbent is used for each observation there is no opportunity for the adsorbent to become saturated or even sufficiently heavily laden with odorant material for its performance to be significantly affected.

If the appearance of a recognizable smell comes with an air-speed of *x* c.c./sec. through an adsorbent column of height *n* cm in tube *C*, the critical time of contact of the air which has been odorized in bottle *B* with the adsorbent *C* will be

$$n/2x \text{ sec (because the effective cross-section of tube } C \text{ is } \frac{1}{2} \text{ cm}^2).$$

For each odorant material the critical time of contact with each of the five adsorbents was measured, although in many cases the fat proved not to adsorb the odorant. Comparison of the critical times of contact for each odorant with the different adsorbents was then made and these times were suitably scaled so that a 'number' characteristic of each smell was obtained. Those odorant materials that had smells of the same kind generally had 'numbers' that were not very dissimilar, as will be seen below.

## RESULTS AND DISCUSSION

The experimental results are given in full for the series of observations made with oil of lemongrass and with *n*-butanol, the first two odorant materials to be used. The detailed experimental observations enable the spread of the separate observations to be assessed. The spread was much the same with the other odorants.

One point that requires explanation is the unevenness of the steps between different heights of the adsorbent column in successive experiments. This arises from the fact that the column was partly filled at the start of each experiment, but its filled height was not read until *after* the critical air speed had been observed. When the observer did not know the height of the adsorbent column, he correspondingly did not know at what air speed (in his second and subsequent observations) to expect the appearance of odour. It was found in practice that this increased the reliability of the results and accordingly the height of adsorbent column was not observed until after the smelling test had been made. For this reason, there was no convenient opportunity to space out the adsorbent column heights for different observations with equal differences.

TABLE 1. Times of contact required for adsorption of oil of lemongrass on various adsorbents

Adsorbent	Height of adsorbent column (cm)	Air speed at which lemongrass odour was first clearly recognizable (c.c./sec)	Critical time of contact of odorized air with adsorbent (sec)	Mean critical time of contact (sec)
Activated carbon	5.0	11.5	0.217	0.212
	6.0	17.0	0.177	
	7.5	15.5	0.242	
	10.5	27.0	0.195	
	12.5	27.0	0.231	
Silica gel	3.0	12.5	0.120	0.129
	4.0	18.5	0.108	
	5.0	21.0	0.119	
	7.5	24.5	0.157	
	8.0	28.0	0.143	
Activated alumina	10.5	22.0	0.239	0.265
	16.1	27.0	0.296	
	19.0	35.0	0.272	
	19.3	40.0	0.241	
	19.5	35.0	0.278	
Activated fuller's earth	7.7	14.5	0.265	0.254
	8.6	17.5	0.247	
	10.0	21.0	0.238	
	13.4	25.0	0.268	
	15.0	30.0	0.250	
Vegetable fat	12.0	16.5	0.364	0.452
	12.1	15.0	0.403	
	12.4	14.0	0.443	
	12.8	12.0	0.533	
	15.5	15.0	0.517	

Using oil of lemongrass, which has a very high content of citral and a powerful lemon-like odour, as the odorant material, the results obtained were as shown in Table 1.

When *n*-butanol was used as the odorant material, the observed results were as shown in Table 2.

TABLE 2. Times of contact required for adsorption of *n*-butanol on various adsorbents

Adsorbent	Height of adsorbent column (cm)	Air speed at which <i>n</i> -butanol odour was first clearly recognizable (c.c./sec)	Critical time of contact of odorized air with adsorbent (sec)	Mean critical time of contact (sec)
Activated carbon	2.0	13.0	0.077	0.079
	2.3	15.5	0.074	
	2.8	15.0	0.093	
	4.3	26.0	0.083	
	5.4	40.0	0.068	
Silica gel	2.6	15.0	0.087	0.086
	2.8	14.0	0.100	
	4.6	38.0	0.061	
	4.8	27.0	0.089	
	5.0	27.0	0.098	
Activated alumina	4.0	10.0	0.200	0.218
	4.8	13.0	0.184	
	10.0	27.0	0.184	
	12.7	24.5	0.260	
	15.0	36.0	0.210	
Activated fuller's earth	2.2	17.0	0.065	0.063
	3.0	19.0	0.079	
	3.8	35.0	0.054	
	4.4	39.0	0.056	
	4.7	40.0	0.059	
Vegetable fat	24.0	10.0	>1.0	Not an effective adsorbent

In a similar way the critical contact times for eleven other materials with the same five adsorbents were measured. The results, including those for oil of lemongrass and *n*-butanol were as shown in Table 3.

The amyl alcohol used throughout was that known as B.S.-696, which is commonly used for milk testing and in which two isomers preponderate.

In those cases where the critical time of contact exceeds 1 sec it is preferred simply to say that the adsorbent is not effective against that particular odorant; it is very unlikely that such a slow process would bear any relation to those processes which accompany olfaction, because smells are usually perceived either quickly or not at all. The lowest critical time of contact is about 0.059 sec, and the highest of which we are taking cognizance is 1 sec. It will be convenient to arrange times within this range on levels which we can denote by the integers 0 to 8, reserving 9 for those times in excess of 1 sec. Further, it will be more realistic to have these levels so that they bear a logarithmic ratio to each other rather than an arithmetical one. This can be

TABLE 3. Times of contact required for adsorption of odorants on various adsorbents

Odorant	Type of odour	Critical time of contact (sec) with				
		Activated carbon	Silica gel	Activated alumina	Activated fuller's earth	Vegetable fat
Amyl alcohol (B.S.-696)	Fusel oil	0.117	0.106	0.338	0.096	>1
n-Butyl alcohol	Spirituos bitter	0.079	0.086	0.218	0.063	>1
Carbon tetrachloride	Spirituos sweetish	0.119	0.263	0.800	>1	>1
Allyl caproate	Pineapple	0.126	0.110	0.297	0.173	0.603
Ethyl acetate	Fruity	0.142	0.110	0.280	0.258	>1
Ethyl lactate	Fruity, rum	0.081	0.062	0.273	0.106	>1
Methyl salicylate	Wintergreen	0.078	0.106	0.331	0.166	0.381
Carbon disulphide	Spirituos, nauseous	0.281	0.507	>1	>1	>1
Pyridine	Rank, repulsive	0.133	0.129	0.487	0.500	0.789
Acetone	Spirituos sweet	0.242	0.170	0.590	0.863	>1
Oil of lemongrass	Lemon-like aromatic	0.212	0.129	0.265	0.254	0.452
Onions	Onions	0.059	0.153	0.730	0.994	>1
Faeces	Faecal, nauseating	0.059	0.080	>1	>1	>1

done conveniently if the increment between one odour level and the next is 37%, so that

0	represents critical times of contact from 0.059 to 0.081,
1	" " " " 0.082 to 0.111,
2	" " " " 0.112 to 0.152,
3	" " " " 0.153 to 0.208,
4	" " " " 0.209 to 0.285,
5	" " " " 0.286 to 0.390,
6	" " " " 0.391 to 0.534,
7	" " " " 0.535 to 0.732,
8	" " " " 0.733 to 1,
9	" " " " higher than 1 sec.

Using this notation we can write the critical times of adsorption (as determined by odour test) for amyl alcohol as

2 on activated carbon,  
 1 on silica gel,  
 5 on activated alumina,  
 1 on activated fuller's earth,  
 9 on vegetable fat,

or we can use the number 21519 to characterize its adsorption properties as determined by odour test. Similarly the information contained in Table 3 can be rewritten as shown in Table 4.

These figures are indicative of adsorption characteristics and have been obtained by olfactory test; they are not necessarily indicative of smell



properties. If, however, adsorption does play an important part in the experience of olfaction, as it is believed to do, then it is very likely that the figures given in Table 4 will be indicative not only of adsorption characteristics but also of odour characteristics. How, in fact, do they appear when viewed in this light?

TABLE 4. Adsorption characteristics of odorants expressed on logarithmic scale

Amyl alcohol (B.S.-696)	2 1 5 1 9	Carbon disulphide	4 6 9 9 9
<i>n</i> -Butyl alcohol	0 1 4 0 9	Pyridine	2 2 6 6 8
Carbon tetrachloride	2 4 8 9 9	Acetone	4 3 7 8 9
Allyl caproate	2 1 5 3 7	Lemongrass oil	4 2 4 4 6
Ethyl acetate	2 1 4 4 9	Onions	0 3 7 8 9
Ethyl lactate	0 0 4 1 9	Faeces	0 0 9 9 9
Methyl salicylate	0 1 5 3 5		

First, all the odorants have different smells and all have different numbers. Conversely all substances that have different numbers, have different smells. Secondly, there are two pairs of substances with somewhat similar smells and with not very dissimilar numbers; thus amyl and *n*-butyl alcohols both have fusel oil bitter type odours and their odour characteristic numbers are:

2 1 5 1 9 amyl alcohol (B.S.-696),  
0 1 4 0 9 *n*-butyl alcohol,

these betraying a family resemblance. Then, again, allyl caproate 2 1 5 3 7 and ethyl acetate 2 1 4 4 9 both have simple fruity smells and both again have odour characteristic numbers which are not very dissimilar. Thirdly, the unique nature of the characteristic number 4 6 9 9 9 of carbon disulphide which has a quite unique and nauseating smell is reassuring; so, too, is the unique nature of the faeces number 0 0 9 9 9.

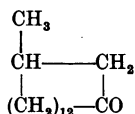
Probably most people would agree that of the thirteen odorants used in this work, those with the most pleasant smells are: allyl caproate, ethyl acetate, and lemongrass, which are characterized respectively by 2 1 5 3 7, 2 1 4 4 9 and 4 2 4 4 6. This prompts the thought that pleasantness of smell may be associated with fairly uniform adsorption on different adsorbents, whilst extremes of difference such as are found in the odour of faeces, 0 0 9 9 9, tend to unpleasantness. This leads to the corollary that uniformity of the spatial activation of the peripheral receptors will lead to pleasant odours, whilst intense *local* activation will lead to unpleasant smells.

#### *Adsorption characteristics of chemically unrelated substances with similar odour*

But although the odour characteristic numbers of *n*-butyl and amyl alcohols were not very dissimilar, it has to be remembered that these two substances are very closely related in chemical constitution. Again, although allyl caproate and ethyl acetate both possess fruity odours and both had somewhat similar adsorption characteristics, there was once again a close, even if

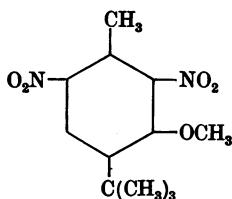
not quite so close, chemical resemblance in that both were esters. The question as to whether the similarity of adsorption characteristics was due to similarity of chemical constitution or to similarity of smell really remained open. It was thought that a crucial test to resolve this question would be to examine the adsorption characteristics of two substances which had similar smells but which were very unlike in chemical constitution.

*Musk and ambrette musk.* The pair of substances chosen for this test was natural Tonquin musk and ambrette musk. The natural musk was in the form of grains and was the dried secretion from the male musk-deer. As has been shown by Ruzicka (1926), the essential principle of musk is 3-methyl-cyclopentadecanone



This macrocyclic ketone, known as muscone, constitutes from  $\frac{1}{2}$  to 2% of natural musk.

Musk is an essential constituent of most perfumes but natural musk is so expensive and rare that a number of synthetics which have odours very similar to that of natural musk are manufactured. One of the most popular of these is ambrette musk which was shown by Zeide & Dubinin (1932) to be 1-methyl-2 : 6-dinitro-3-methoxy-4-*tert*-butylbenzene



In chemical constitution it could hardly be more remote from muscone, and yet its smell is very similar to, although certainly not quite the same as, that of natural musk.

When trials with these two substances were made along the lines already described, the smell of the odorized air, i.e. of the air that had been passed over either the musk grains or the crystalline ambrette musk was not instantly recognizable. Although musks of all kinds have extremely persistent smells, these smells are not very intense, because the musks have extremely low vapour pressures. Those of both muscone and ambrette musk are of the order of only 0.001 mm Hg. In order to intensify their odours so that measurements could be made easily, it was necessary to raise their vapour pressures and this was done by warming them. The bottle *B*, containing either of the musks, was immersed in a water-bath at 55° C; this greatly increased the vapour pressure

of the musk and the odour in air that had been blown over it was thereby rendered so intense that there was no difficulty at all about detecting the appearance of the odour.

Results obtained were as shown in Table 5.

TABLE 5. Adsorption time for two musks

Odorant	Critical time of contact (sec) with				
	Activated carbon	Silica gel	Activated alumina	Activated fuller's earth	Vegetable fat
Natural musk	>1	>1	>1	>1	>1
Ambrette musk	>1	>1	>1	>1	>1

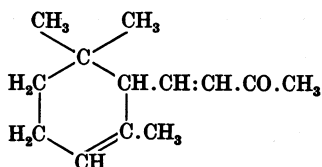
The surprising result emerged that in neither case was any of the five adsorbents used effective. In other words, musk, whether natural or 'ambrette', cannot be at all efficiently adsorbed by activated carbon, silica gel, activated alumina, activated fuller's earth or vegetable fat. Here were two substances unrelated in every way except in similarity of smell, which showed the most unusual and unexpected resistance to adsorption. When it is remembered that the odour of natural musk is designed to attract animals of the opposite sex from a distance of some miles, and when the very low vapour pressure of musk itself is recalled, it is clear that the vapour must be in an extremely tenuous form when it is perceived by the female deer. If musk vapour could easily be adsorbed, e.g. on timber, on leaves, or on minerals, it would have very little chance to spread and still to be perceptible over the very large areas that it undoubtedly is. Perhaps the resistance of musk to adsorption is a provision on the part of nature to ensure that its warning odorant molecules shall have a chance to reach the appropriate animals even at considerable distances.

There was, however, one point to check. Whereas the measurements shown in Table 3 had been made with the odorant material in every case at room temperature, these later measurements with musk had been made with the odorant at about 50–55° C. A check run was therefore made with *n*-butyl alcohol at 55° C and it was found that both activated carbon and silica gel would completely adsorb it without difficulty. It should be noted that although the odorant material was kept at an elevated temperature, the air that was passed over it was in the heated bottle for only such a relatively short time that it was not appreciably warmed.

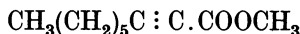
So far as concerned the behaviour of the two musks, the results were unexpected, but they did confirm, so far as they showed anything at all, that behaviour towards adsorbent was similar if smell was similar, irrespective of differences of chemical constitution. In view, however, of the abnormal resistance of the musks to adsorption, it seemed all the more necessary to

make a comparison of the adsorbent properties of two other odorants with similar smells but dissimilar chemical constitution.

*α-Ionone and methyl octine carboxylate.* Both *α*-ionone and methyl octine carboxylate have powerful violet odours; these are not quite the same, but they do have a very obvious similarity when smelt. Their chemical constitutions are very different: *α*-ionone is a ketone with a ring structure



whereas methyl octine carboxylate is a straight chain ester



Both substances have relatively high vapour pressures and there was no difficulty at all about making adsorption tests with them at room temperature. Using the method described earlier in this paper, their critical times of contact with five different adsorbents were ascertained and were as shown in Table 6.

TABLE 6. Adsorption times for two substances with violet odours

Odorant	Critical time of contact (sec) with				
	Activated carbon	Silica gel	Activated alumina	Activated fuller's earth	Vegetable fat
<i>α</i> -Ionone	0.086	0.084	0.145	0.115	0.700
Methyl octine carboxylate	0.150	0.106	0.199	0.125	0.465

It is at once evident that there is a considerable degree of correspondence in the critical times of adsorption of *α*-ionone and methyl octine carboxylate towards the five adsorbents used for test. If these critical times are converted to the logarithmic scale shown on p. 460, we obtain:

<i>α</i> -Ionone	1 1 2 2 7
Methyl octine carboxylate	2 1 3 2 6

which again demonstrates the similarity but not identity of adsorption characteristics. Inasmuch as the odours of *α*-ionone and of methyl octine carboxylate are somewhat similar but not exactly the same, the agreement is reasonable, and supports the thesis that the adsorption behaviour of an odorant material is more closely related to the quality of its odour than to its chemical constitution. One cannot but observe the very low critical times of contact which both of these violet smelling compounds have for four of the five adsorbents used; of all the odorant materials used in this work they are

much the most easily adsorbed and it seems likely that this very rapid adsorption may well be the cause of the familiar evanescence or fleeting nature of the violet perfume.

## SUMMARY

1. Experiments have been carried out to test the hypothesis that the odour of a substance depends on its adsorption characteristics.
2. An objective technique is employed in which the subject is required only to state the time at which an odour becomes recognizable.
3. It has been shown that substances that have different odours do behave differently towards adsorbents but that substances which have odours of the same general type, e.g. fruity, behave not very differently amongst themselves to the adsorbents.
4. A comparison has been made of the adsorption behaviour of compounds of very similar odour but of very unlike constitution. The results of these experiments indicate that the adsorption behaviour is related to the smell and that it is not obviously related to the chemical constitution.

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